

Initial Ideas Pitch

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<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> • Fish feed for sustainable aquaculture, courtesy of engineered yeast • The Gates Foundation Grand Challenge, Blue Economy Challenge #1: Rethinking Feed for Aquaculture • Alternative ways of supplying fish nutrients
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>Consider the following dimensions when considering the impact of the opportunity:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> • Aquaculture plays a massive role in feeding the growing world population • Current aquaculture feed made from inedible wild fish species is very inefficient and unsustainable • Synthetic biology fish feed could replace the need for feeder fish, simultaneously stopping overfishing of these species and allowing for sustainable aquaculture to help feed the growing population. • Ethical, economic and societal consequences of negative effects of replacement fish feed on fishing industries that catch feeder fish species • Hurts the livelihood of the people and industries who catch these species
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> • Grow or raise or harvest alternative sources, possibly from agriculture, to provide the nutrients aquaculture fish species need
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> • Fishing industries and fishermen that catch wild feeder fish species used in current fish feed will be negatively affected. • Aquaculture farms will be quick to

	adopt a sustainable, greener, more efficient fish feed.
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DNA Data Compression

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> • Create a method to produce a smaller version of a gene • Indicates how to recreate the original gene when gene is expressed • Produces same effect as the original • Inspired by zipped files and WinRAR and 7zip
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>Consider the following dimensions when considering the impact of the opportunity:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> • Fit more genes into a smaller chassis • Further increase efficiency of storing digital data in DNA • Make synthetic biology more efficient by allowing more genes and pathways to be engineered into a single cell
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> • Multicellular-level engineering • Split pathways, genes and functions among different populations of cells in a synthetic consortia instead of putting more genes into a single cell
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> • Synthetic biologists will have further increased engineering capabilities. WinRAR will finally be given recognition for their contributions to society.

Silica

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Inspired by silica used in modern computing and telecommunications technologies - Silica is abundant in nature - It can be manipulated by biological organisms
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	<ul style="list-style-type: none"> - Believe that microbes can produce large quantities of organized silica structures without hazardous waste and arduous manufacturing processes - N/A <p>Societal:</p> <ul style="list-style-type: none"> - If we could easily produce biogenic silica, there are opportunities for it to be used to manufacture things like solar cells and touch screens. <p>Economic:</p> <ul style="list-style-type: none"> - The process of making biogenic silica would be more cost effective than current manufacturing processes. Cells only require a feedstock and silica particles to produce organized structures. <p>Environmental:</p> <ul style="list-style-type: none"> - Hazardous chemicals typically used to process silica could be avoided. <p>Ethical:</p> <ul style="list-style-type: none"> - N/A <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - N/A
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Making silica is already a cheap and easy process. - We could develop the idea to determine if it would have benefits

	which outweigh current practices.
Outcomes Who might care what you do and how you do it? What happens now?	<ul style="list-style-type: none"> - People who manufacture silicon chips or other silica based parts to improve their environmental practices. - Further research must be conducted to determine the feasibility of the project.

Crop Drought Protection

Opportunity What are you doing? How did you become aware of the application/technology/idea?	<ul style="list-style-type: none"> - Developing method of saving crops from extreme weather conditions by pre-emptively inducing a stress response. - After researching GMOs, we realized that there were many opportunities for synthetic biology to be applied agriculture. Synthetic biology can extend the life of produce, increase crop yield, and help restore fertile farm land.
Considerations Why are you doing it? Why does this decision need to be made? What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity? Please consider the following dimensions: <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	<ul style="list-style-type: none"> - We know that by 2030, food demand will increase by 50% due to our growing population.¹ Increasing the amount of food we produce is important. Societal: <ul style="list-style-type: none"> - We could help farmers in developing countries increase their crop yield by making their plants more hearty. Economic: <ul style="list-style-type: none"> - We could increase farmer's yields through our system and make more produce for them to sell. Our system would be more cost effective than producing current anti-drought chemicals.

	<p>Environmental:</p> <ul style="list-style-type: none"> - We would be releasing genetically modified organisms into the environment, which could potentially have adverse effects. Many people are strongly oppose genetically modified organisms because of their unknown long term effects on our health and the environment. <p>Ethical:</p> <ul style="list-style-type: none"> - The long term health risks associated with consuming GMO's is unknown. <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - Agriculture is cool!
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Continue with current farming practices, which are already very effective. - There are technical challenges we might not be able to overcome regarding the pathway for the production of stress response chemicals. We might also not be able to contain the organisms. - We could create kill switches which destroy the GMO's which secrete the chemicals which induce the stress response in the plants.
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - The general public might not want to add more genetically modified organisms into the environment. - The idea should not be developed.

Cell Free AMPs

<p>Opportunity What are you doing?</p>	<ul style="list-style-type: none"> - Developing cell-free antimicrobial peptides. They are proteins which
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How did you become aware of the application/technology/idea?	<p>disrupt the cell membranes of potentially pathogenic microbes.</p> <ul style="list-style-type: none"> - The Biomimetics course taken by Bioengineers in second term raised awareness about the technology.
<p>Considerations</p> <p>Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	<ul style="list-style-type: none"> - Antimicrobial resistance is a big deal so there is a need to develop therapeutic that can target antibiotic resistant strains of bacteria - People are dying all around the world due to antibiotic resistant bacteria <p>Societal:</p> <ul style="list-style-type: none"> - Lives would be saved thus improving quality of life for all that would be otherwise affected <p>Economic:</p> <ul style="list-style-type: none"> - Frees up beds in hospitals if these illnesses become curable <p>Environmental:</p> <ul style="list-style-type: none"> - Less demanding on the environment than current chemistry based pharmaceutical procedures <p>Ethical:</p> <ul style="list-style-type: none"> - As a drug for humans, the system would have to reach FDA standards <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - Lives would be saved and quality of life improved
<p>Alternatives</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Cell based manufacture but no known therapeutics are currently available - However the issue with GMOs would arise due to cell based manufacture.
<p>Outcomes</p> <p>Who might care what you do and how you do</p>	<ul style="list-style-type: none"> - Everyone would care, most importantly the FDA and the WHO

it? What happens now?	<ul style="list-style-type: none"> - Idea was not continued as it was thought that MIT were already further ahead than us
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Tunnel forming Bacteria

Opportunity What are you doing? How did you become aware of the application/technology/idea?	<ul style="list-style-type: none"> - Developing tunnel forming bacteria. - Inspired by concept described in the book Bio Designs.
Considerations Why are you doing it? Why does this decision need to be made? What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity? Please consider the following dimensions: <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	<ul style="list-style-type: none"> - Deserts make 1/3 of the Earth's land surface. Tunnel forming bacteria could cheaply irrigate those locations. - N/A <p>Societal:</p> <ul style="list-style-type: none"> - We could increase the amount of fertile land for farming, which would feed the increasing global population. It might disrupt the cultural practices of populations which live in the desert. <p>Economic:</p> <ul style="list-style-type: none"> - Terraforming large swaths of deserted land is expensive and time consuming. Microbes could do it with little maintenance. More farmland means more economic opportunities for food production. <p>Environmental:</p> <ul style="list-style-type: none"> - Might negatively impact organisms which thrive in desert environments. <p>Ethical:</p> <ul style="list-style-type: none"> - Might increase the amount of soil which is washed away each year into the ocean. Thus, perpetuating the issue of monocropping plants with shallow roots and washing away even more soil.

	Material: - N/A Emotional: - N/A
Alternatives How could you do it/move forward differently? What are the options to respond to the stimulus?	- Advocate for better farming practices. Choose a different application than increasing the amount of farmland in the desert. - Choose a different project idea.
Outcomes Who might care what you do and how you do it? What happens now?	- Environmentalists might argue that our solution will perpetuate a problem rather than help to solve it. Terraforming the earth might have unintended negative consequences on certain communities and ecosystems. - Choose a different project idea.

Self-Sustaining Raft

Opportunity What are you doing? How did you become aware of the application/technology/idea?	- Developing arable land on water using a self-sustaining raft. -
Considerations Why are you doing it? Why does this decision need to be made? What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity? Please consider the following dimensions: <ul style="list-style-type: none"> - Societal - Economic 	- Water covers 71% of the Earth's surface. - N/A Societal: <ul style="list-style-type: none"> - We could increase the amount of fertile land for farming, which would feed the increasing global population. - Would disrupt current cultural practices and farming methods of farmers.

<ul style="list-style-type: none"> - Environmental - Ethical - Material - Emotional 	<ul style="list-style-type: none"> - Possible conflict of interest between farmers and fishermen if the rafts are set up on zones which are used for aquaculture. <p>Economic:</p> <ul style="list-style-type: none"> - Farmers would need new tools that are compatible with the raft for seeding and harvest. Microbes could sustain and renew the nutrient in the arable earth on the raft with little maintenance. More farmland means more economic opportunities for food production. <p>Environmental:</p> <ul style="list-style-type: none"> - Might negatively impact organisms which thrive in water environments. - If material is used to make the raft it could degrade and pollute the environment <p>Ethical:</p> <ul style="list-style-type: none"> - Might increase the amount of pollution from water transportation. <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - N/A
<p>Alternatives</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Advocate for better farming practices. Choose a different application than increasing the amount of farmland on ocean. - Choose a different project idea.
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - Environmentalists might argue that our solution will disrupt the environment. Farmers may not like the idea of farming on water - Choose a different project idea.

References:

1. Water and food security | International Decade for Action 'Water for Life' 2005-2015.

Syn Bio Olympics

Opportunity What are you doing? How did you become aware of the application/technology/idea?	<ul style="list-style-type: none">- Developing the Synthetic Biology Olympics (genetically engineering the fastest bacterias.)- Inspiration was drawn as it is Olympic Year
Considerations Why are you doing it? Why does this decision need to be made? What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity? Please consider the following dimensions: <ul style="list-style-type: none">- Societal- Economic- Environmental- Ethical- Material<ul style="list-style-type: none">- all of the physical objects that people create and give meaning to- Emotional	<ul style="list-style-type: none">- A way to get the public involved in synthetic biology and to reduce the dogma surrounding it- Synthetic biology is still not as well receive as scientists would want it to be- Is this the best way to get the public involved.- Societal: Gives the public something to get excited about and relate to synthetic biology- Economic: Is it just a drain of money, should we be focussing more on practical research- Environmental: Release of GM microorganisms may occur- Material:- Emotional:
Alternatives How could you do it/move forward differently? What are the options to respond to the stimulus?	<ul style="list-style-type: none">- Find a practical way to creating interest for synthetic biology- Do something that would be immediately beneficial for the public
Outcomes Who might care what you do and how you do it? What happens now?	<ul style="list-style-type: none">- The masses. Engineering the bacteria would require the standard cycle for the development of synthetic biology ideas- Idea was dropped due to the fact it doesn't have a tangible benefit to

	research
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Neural Networks

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Developing an image processing system using bacteria akin to a neural network - Idea was based on artificial neural networks developed to process images i computers
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - Low cost population based processing. Would be a step towards biological computers. - Biological computation is garnering interest world wide - Need the system to show enough promise that it would (eventually) be compared to image processing in computers - Societal: Gives the public something to get excited about and relate to synthetic biology - Economic: Money could be saved using this technique - Environmental: Release of GM microorganisms may occur - Material: A working prototype computer may be developed at the end of the design process. - Emotional:n/a
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Developing an alternative system - No other options have been theorised as neural networks are still being developed but others may come about
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - The masses. Engineering the bacteria would require the standard cycle for the development of synthetic biology ideas - Idea was dropped due to the fact it

	was too complex for a 3 month project
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Sonogenetics

Opportunity What are you doing? How did you become aware of the application/technology/idea?	<ul style="list-style-type: none"> - Using Sound to control bacteria - Optogenetics (using light to control bacteria) has been around for a while so sound is the next logical step
Considerations Why are you doing it? Why does this decision need to be made? What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity? Please consider the following dimensions: <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - Sound travels faster through media such as water faster than light so it would allow for faster bacterial control - Faster bacterial control allows for better temporal resolution of systems - Societal: Applications could result in better quality of life - Economic: Could save money by reducing time taken for circuits to function. - Environmental: May involve release of GM microorganisms - Material: New circuits could be developed as a result of faster temporal resolution - Emotional:
Alternatives How could you do it/move forward differently? What are the options to respond to the stimulus?	<ul style="list-style-type: none"> - Keep developing optogenetics and similar methods - Don't do this project and pursue something that uses current technologies
Outcomes Who might care what you do and how you do it? What happens now?	<ul style="list-style-type: none"> - The masses and scientists alike. The system could be used by scientists to develop systems that would benefit the masses - Idea was dropped due to the fact it is

	a very high risk project for IGEM.
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Turing Machines

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Implementing the basic mechanism of a Turing machine into a genetic circuit to carry out simple computational functions.
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - Turing machines are an example of CPUs and if multiple Turing machines could be made with different functions a universal Turing machine could be produced, hence paving the way for biological computing. - Explore and expand the capabilities of “biocomputers”. - The functionality of the system must be expandable, either now or in the future, to resemble that of non-biological computers. - Societal: Provides a link between a well known/common technology and synthetic biology allowing for easier access to the non-synthetic biologist. (Makes synthetic biology more relevant as it relates to a topic currently made more popular in society by the film The Imitation Game) - Economic: Biological computing has the potential to become cheaper than current technology. - Environmental: Potential hazardous release of genetically modified organisms - Ethical: n/a - Material: n/a - Emotional: n/a
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - An alternative circuit could be theorised. - A different approach would not use multiple orthogonal quorum sensing systems to overcome the problem of a

	lack of orthogonal parts.
Outcomes Who might care what you do and how you do it? What happens now?	<ul style="list-style-type: none"> - Researchers in the field who could potentially use and further develop the project. - The idea was cut as it was not feasible in the time period of the project.

Gro Model

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Modelling the behaviour of our circuitry stochastically - Producing a visual model to better communicate the dynamics of our circuit. - [Was recommended to us by Guy]
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - To compare the results of stochastic modelling with the deterministic modelling done in MATLAB. - To better communicate the dynamics of our circuitry. - To produce a visual to further engage [the public/everyone] - The model must realistically resemble the system by including the same mathematical model to produce a visual aid to the modelling of the project and graphical representation of the stochasticity to ... - Societal: Provides a platform for communication of our circuit with the wider [society/community] making synthetic biology more accessible to [the public]. - Economic: n/a - Environmental: n/a - Ethical: n/a - Material: n/a - Emotional: n/a
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Stochastic modelling could be done in MATLAB via population modelling however this would not produce an engaging visual.
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - (Those wishing to follow the progress of the project may benefit from a visual model and would otherwise struggle to take an interest in the modelling side of the project).

Biocontainment

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Developing a standardized framework for biocontainment of genetically modified bacteria - Many iGEM project, particularly those in the environmental track, are limited by the repercussions of releasing GMOs
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - To facilitate the safe deployment of GMOs in the environment - Because the potential repercussions of releasing GMOs into the environment are significant - Societal: Could improve public perception of GMOs - Economic: Could enable potentially cheap biotechnologies that have thus far been avoided for fear of GMO release - Environmental: Avoid the issues associated with GMO release, e.g. unintended consequences on biodiversity - Ethical: See above. - Material: n/a - Emotional: People may have an aversion to manipulating living things in this way?
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Limit the use of GMOs to controlled environments (e.g. bioreactor) - Focus on developing existing technologies for biocontainment
<p>Outcomes Who might care what you do and how you do it?</p>	<ul style="list-style-type: none"> - Environmental groups - Farmers - Regulatory bodies

What happens now?

- Researchers
- Industry (esp. agriculture)
- Locals residents

Biocomputation

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Producing a 4-to-1 multiplexer as a step towards biocomputing. - This project was inspired by a previous project idea involving Turing machines
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - A lot of digital systems are based on multiplexers. - Explore and expand the capabilities of “biocomputers”. - The functionality of the system must be expandable, either now or in the future, to resemble that of non-biological computers. - Societal: Provides a link between a well known/common technology and synthetic biology allowing for easier access to the non-synthetic biologist. - Economic: Biological computing has the potential to become cheaper than current technology. - Environmental: Potential hazardous release of genetically modified organisms - Ethical: n/a - Material: n/a - Emotional: n/a
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - An alternative circuit could be theorised. - A different approach would not use multiple orthogonal quorum sensing systems to overcome the problem of a lack of orthogonal parts.
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - Researchers in the field who could potentially use and further develop the project. - The idea was cut as it was not feasible in the time period of the project.

Anticoagulant Blood Sensor

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Making a cell free anticoagulant detecting patch. - An MIT Technology Review article was published about an electronic anticoagulant sensor.
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What are the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following criteria:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - Many elderly patients are prescribed “blood thinners.” Patients need to go to weekly check-ups at their doctor’s office to test if they are in the therapeutic range of the drug. If they had a sensitive, easy to use, blood testing technology they could ensure they are in the therapeutic range of the drug. <p>Societal:</p> <ul style="list-style-type: none"> - It is inconvenient and potentially dangerous for patients to have to go the doctor’s office once per week. <p>Economic:</p> <ul style="list-style-type: none"> - Cell free patches would be cheap to produce. They would be more sensitive than their electrical counterparts. They would also be more reliable, because they do not require an energy source. <p>Environmental:</p> <ul style="list-style-type: none"> - The patches could potentially be nonbiodegradable. <p>Ethical:</p> <ul style="list-style-type: none"> - N/A <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - Drawing blood for testing is painful and potentially traumatic for some

	patients.
Alternatives How could you do it/move forward differently? What are the options to respond to the stimulus?	<ul style="list-style-type: none"> - Find a better way of determining the level of anticoagulant drugs in the body rather than drawing blood. - Determine how much synthetic biology is required to execute the project, as it seems it is more chemistry based project.
Outcomes Who might care what you do and how you do it? What happens now?	<ul style="list-style-type: none"> - Patients might be more happy that they can test themselves from the comfort of their own home. Doctors might be more happy because they do not need to have as many visits with patients, freeing them to do other things. - Further explore the technical challenges of the project, although it does not seem to be an appropriate project in this context.

Synthetic Gelatine

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Producing bacterial synthetic gelatin - By talking to vegans and students who cannot eat pork-based or bovine-based gelatin (44% of produced gelatin in pork based), and who are not satisfied with the taste and texture of agar jelly.
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>Consider the following dimensions when considering the impact of the opportunity:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - To propose an alternative way to produce gelatin that does not involve the hydrolysis of collagen coming from skin, bones and connectives tissues of cattle, chicken, pigs, horses and fish. - Produce gelatin to be used as a gelling agent in cooking (yogurts, ice creams, candies, soft drinks, etc), pharmaceutical capsules and in cosmetics. <p>Societal:</p> <ul style="list-style-type: none"> - Some people cannot eat animal based gelatin because of personal or/and religious convictions. Develop a product to respond to their need. Only 1% of produced gelatin is non-animal based. - Trends towards healthy lifestyles. <p>Economic:</p> <ul style="list-style-type: none"> - Gelatin market has been estimated to \$1.8 billion and is estimated to reach \$4.08 billions by 2024. <p>Environmental:</p> <ul style="list-style-type: none"> - Producing gelatin from pork-skin involves the use of acids. It also involves several washing and drying steps, which require large amounts of water and energy. These processes therefore have a significant impact on the environment. <p>Ethical:</p> <ul style="list-style-type: none"> - NaN

	Material: - NaN Emotional: - People may feel disgust about the whole gelatin process chain.
Alternatives How could you do it/move forward differently? What are the options to respond to the stimulus?	- Use agar as a gelling agent, which is already quite cheap.
Outcomes Who might care what you do and how you do it? What happens now?	- Vegans and non pork eaters may be happier to be able to choose from a larger set of gelatin-based products. - Plant-based gelatin products are easy to produce and may be less controversial than bacterial gelatin. It does not feel appropriate to continue further on the project as there already exist viable alternatives.

Air Pollution Drone Detector

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Making a pH based air pollution detector that will be attached to a drone - China using drones to monitor air pollution
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	<ul style="list-style-type: none"> - Believe that drones can be used to analyse air quality remotely without supervision - Developing cheaper and more effective ways of managing air pollution is absolutely necessary to reach the targets set out by the Paris Climate Agreement 2015 <p>Societal:</p> <ul style="list-style-type: none"> - Make it harder for industrial companies and factories to escape emission violations. <p>Economic:</p> <ul style="list-style-type: none"> - Prices of remote control drones have reduced a lot while their performance keeps increasing. - National pollution monitoring systems have received a lot of investment while their efficacy is still proving doubtful. <p>Environmental:</p> <ul style="list-style-type: none"> - This might be a way for allow businesses, families to manage their air quality more closely. <p>Ethical:</p> <ul style="list-style-type: none"> - Potentially releasing concentrated amounts of toxic pollutants if the drone crashes or collapses. <p>Material:</p> <ul style="list-style-type: none"> - Material used for encasing might not be robust enough for all weather conditions. It may have short lifespan. - Might not be enough space to integrate all different detectors into a

	<p>small space.</p> <p>Emotional:</p> <ul style="list-style-type: none"> - Inspired the popularity of drones, especially with Professor Freemont and the team.
<p>Alternatives</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Reducing the weight and flight range of drones. - Developing and testing cheaper and Synthetic biology inspired sensors for different pollutants to determine whether these are more effective than existing ones.
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - Environmentalists - The Environment Secretary, Government - Industrial companies who have set emission targets - Focus more on technologies which don't rely on sending potentially toxic chemicals into the environment unsupervised.

Desktop Bioreactor

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<p>Implementing our ratio control system into a desktop bioreactor designed for the home to produce customizable probiotics.</p> <p>Research specifically into the consumer discretionary field of applications led to a project from the MIT media lab including the design of a prototype desktop bioreactor.</p>
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>Consider the following dimensions when considering the impact of the “opportunity”:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<p>To provide individuals with customizable probiotic supplements so that this science is accessible in the home.</p> <p>To explore whether personalizable medicine is an accessible area of the market in which our product will be useful.</p> <p>Societal: Reduces burden on public health services. Improves public health as the drugs are more accessible potentially encouraging individuals to take them. Potential issues with the public being in charge of GMOs at home.</p> <p>Economic: Potentially reduces needs of pharmaceutical companies as the individual can produce their own probiotics and no longer need to rely on the industries. Pharmaceuticals is a large, economically affluent sector.</p> <p>Environmental: Is a more sustainable way of producing probiotics.</p> <p>Ethical: Potential issues with the public being in charge of GMOs at home.</p> <p>Emotional: Dosage is under the individual's control and not regulated by professionals and hence is subject to emotions and views of the individual. Although overdosing on probiotics is highly unlikely, large quantities could unhealthy.</p>

<p>Alternatives</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Research approaches to producing a minimal system in which the individual has less control over the system. - Further develop the safety protocols and rules associated with at home genetically modified systems.
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - The individual who would use / invest in the technology. - Pharmaceutical companies who currently provide the probiotics. - Doctors and the healthcare industry as this could provide additional health problems / irresponsible use of probiotic supplements.

Initial Ideas Pitch #2/1st of July

Presentation

Optogenetic DNA Recoding

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<p>A system for real-time recoding of DNA, without the need for DNA synthesis and transformation. A digital DNA sequence is converted into a sequence of light pulses, which are subsequently 'written' as corresponding nucleotides <i>in vivo</i>.</p> <p>This idea was mainly inspired by optogenetics, the control of gene expression using external light, which was encountered during lectures at Imperial. We wanted to expand optogenetics to also be used to control the cell's synthesis of new DNA/genes.</p>
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>Consider the following dimensions when considering the impact of the opportunity:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<p>With current digital technology we can use a computer (ie. a machine) to reprogram or add new functionality (eg. apps, files, data, etc) to other devices and machines (eg. phones, USBs) in a relatively straightforward manner.</p> <p>This is simply not true with current biology-based technology. Extensive lab facilities and protocols must be followed to attempt to reprogram or add even very simple functionality to cells via synthesized DNA.</p> <p>Our relationship with biology-based technology is nowhere near as intuitive as the relationship we have with digital technology, where we can make and test changes, updates and additions on a whim. Implementation of this idea would allow that. Biology would further become just another tool at our disposal.</p> <p>The immediate consequences of implementing this idea would be mostly</p>

	<p>economic and material. Most of the lab technology that facilitates biotechnology would become redundant. Industries producing life science lab technologies would be changed irreversibly. A significant proportion of the industry would disappear entirely.</p> <p>The ethical, societal and emotional consequences would be no less profound. If creating new functionality for biology could be done primarily using a laptop, almost anyone would be able to do it anywhere. The ability to do this would be almost completely democratized and available to anyone regardless of their agenda, possibly even more so than software. The regulation of biology, biotechnology and wetware by the law and government would have to change and adapt very quickly to keep up. Our view of biological life would be irreversibly changed. Biology would now become a technology just like electronics or software and regulated as such and no longer primarily a phenomenon to be studied. This change of perspective would also translate to how we view ourselves, as humans are part of nature and biology as well.</p>
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<p>Further developing conventional life science hardware and software that facilitates the reprogramming of cells could also move this idea forward. Making these technologies more efficient, cheaper, intuitive, easier to use, user-friendly, automated and accessible would be another option to achieve the overarching goal of simplifying and democratizing the reprogramming of biology.</p>
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	<p>Scientists and creators of life science lab technology would initially be affected the most, as the lab technology industry would change completely as life scientists adopt this vastly superior method of reprogramming biology. Designers, biohackers, engineers and other creators would also be immediately affected by biology now becoming a much easier technology to modify and create with.</p>

	Government and lawmakers would also be affected by this very powerful, democratized technology that would require regulation.
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Protocol for Reflexivity

Swarm

Opportunity What are you doing? How did you become aware of the application/technology/idea?	Creating a controlled bacterial swarm with a leader and follower population. Can possibly be combined with associative learning. Can be used for exploring new environments, drug delivery in the body or bioremediation
Considerations Why are you doing it? Why does this decision need to be made? What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity? Please consider the following dimensions: <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	Societal benefits of bioremediation, cleaning up of hazardous toxic waste. Also related health and environmental benefits. Ethical considerations of releasing bacterial swarms in human body. Concerns over willingness of public to accept this. There are also potential health concerns related with this. Environmental benefits of sending bacterial swarms to explore areas unable to be explored by man. Gain greater understanding of these areas, may even be able to retrieve samples for testing. Concerns over how to suppress other tactic responses in the bacteria, to ensure they follow the leader population.
Alternatives How could you do it/move forward differently? What are the options to respond to the stimulus?	Find an application which has fewer concerns regarding release of bacteria in natural environments/body If such an application is not found, then drop the project idea
Outcomes	Environmentalists would have concerns over

Who might care what you do and how you do it?	the release of bacteria into widespread environments
What happens now?	Choose a different project idea

Opportunity What are you doing? How did you become aware of the application/technology/idea?	<ul style="list-style-type: none"> - Making synthetic wood using bacteria
Considerations Why are you doing it? Why does this decision need to be made? What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity? Please consider the following dimensions: <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - We could make wood that was strong and fire resistant - Societal <ul style="list-style-type: none"> - Everyone uses wood! If we can improve the structural properties of wood, can make it a more desirable building product - Economic <ul style="list-style-type: none"> - If we can make bacterially-produced - Environmental <ul style="list-style-type: none"> - Deforestation due to logging could be slowed - Ethical <ul style="list-style-type: none"> - N/A - Material <ul style="list-style-type: none"> - Wood? - Emotional <ul style="list-style-type: none"> - Again, people feel an emotional connection to eco friendly products
Alternatives How could you do it/move forward differently? What are the options to respond to the stimulus?	Can we modify non-structural qualities of the wood? Add color, coatings, etc?
Outcomes Who might care what you do and how you do it?	-Dead

What happens now?	
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Project Update #1

Protocol for Reflexivity

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Production of oxygenated taxanes, which are anticancer drugs. - Possibility of producing new taxanes more efficiently.
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	<p>Societal:</p> <ul style="list-style-type: none"> - Cancer kills millions of people - Improved efficiency of taxane production through co-culture could make more life saving medicine <p>Economic:</p> <ul style="list-style-type: none"> - More efficient pathway means more drugs could be made more cheaply which means lower cost for hospitals which means money could fund <p>Environmental:</p> <ul style="list-style-type: none"> - N/A <p>Ethical:</p> <ul style="list-style-type: none"> - Taxanes could be linked to cardiac toxicity, secondary leukemia, diminished cognitive function, and neurotoxicity¹ <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - N/A
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - More efficiently produce established cancer drugs. - Producing a more simple drug.
<p>Outcomes Who might care what you do and how you do</p>	<ul style="list-style-type: none"> - Rejected idea because of technical problems with quorum sensing

<p>it?</p> <p>What happens now?</p>	<p>between different species</p> <ul style="list-style-type: none"> - Rejected idea producing a drug is very complicated and requires too much time to be completed - Rejected idea because there are already many existing cancer therapies
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<p>Opportunity</p>	<ul style="list-style-type: none"> - Produce of “bone glue” which would act as a wet adhesive with embedded silica nanospheres. <ul style="list-style-type: none"> - The glue would be used to fill bone defects and stimulate new bone growth
<p>Considerations</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	<p>Societal:</p> <ul style="list-style-type: none"> - Bone is second most transplanted tissue besides blood - Not all bone damage can be repaired, which means permanent restricted mobility for patients <ul style="list-style-type: none"> - Patients have a diminished quality of life <p>Economic:</p> <ul style="list-style-type: none"> - Extracting bone tissue from the patient or other donors is an expensive and arduous process - Bone glue would be easier to make <p>Environmental:</p> <ul style="list-style-type: none"> - N/A <p>Ethical:</p> <ul style="list-style-type: none"> - Implanting something into the body requires careful risk assessment and evaluation by various regulatory bodies <ul style="list-style-type: none"> - Bone glue might travel to other parts of the body and have unintended effects - Bone glue could be rejected

	<p>by the body and increase the size of the defect</p> <ul style="list-style-type: none"> - Bone glue could have permanent, debilitating effects <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - Bone glue is cool!
Alternatives	<ul style="list-style-type: none"> - Could have other applications external to the human body <ul style="list-style-type: none"> - Wet adhesive can repair ships - Might have unintended environmental impacts because of the composition of the glue
Outcomes	<ul style="list-style-type: none"> - Rejected because of technical requirements for the stimulation of new bone growth - Rejected because cells need to be lysed and solution needs to be purified to extract useful components

Opportunity	<ul style="list-style-type: none"> - Produce cellulose-silica “aerogel” <ul style="list-style-type: none"> - “a solid material of extremely low density, produced by removing the liquid component from a conventional gel” - Super light, and excellent insulating properties
Considerations <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	<p>Societal:</p> <ul style="list-style-type: none"> - Create insulation for spaceships - Super strong in compression, could be used as novel building material - Cellulose-silica could be used as a new type of body armour <p>Economic:</p>

	<ul style="list-style-type: none"> - The chemical process for creating aerogels is expensive and difficult <ul style="list-style-type: none"> - Extremely low yields of usable material are produced - A cell based system for making aerogels could be cheaper and create higher yields of the material <p>Environmental:</p> <ul style="list-style-type: none"> - Reduce the toxic waste products from current methods of producing aerogels <p>Ethical:</p> <ul style="list-style-type: none"> - N/A <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - Aerogels are cool!
Alternatives	<ul style="list-style-type: none"> - Could produce another kind of simple biomaterial <ul style="list-style-type: none"> - Aerogels are complicated materials
Outcomes	<ul style="list-style-type: none"> - Rejected

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<p>Bioremediation using co-cultures</p> <p>Consortia of E. Coli and Ochrobactrum can be used to remove Methyl Parathion (toxic insecticide)</p>
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p>	<p>Methyl Parathion has been classified as 'extremely hazardous' by the World Health Organisation. It is highly toxic by ingestion, inhalation and dermal adsorption, but this insecticide is not banned in many developing countries.</p> <p>Societal benefits of reduced hazardous waste</p>

<p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	<p>in the environment</p> <p>Emotionally positive, as fewer health risks associated with inhalation etc of MP</p> <p>Ethical considerations of releasing bacteria into the environment</p> <p>Environmental - positive benefits of cleaning up hazardous toxic waste</p> <p>Economic - huge cost involved with widespread clean-up efforts</p>
<p>Alternatives</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<p>Can this be done without co-culture?</p> <p>If above is not possible, then choose another project idea</p>
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	<p>Governments of countries in which it would be used - concerns over release of bacteria in environment</p> <p>Choose another project idea</p>

<p>Opportunity</p> <p>What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Produce PHA from wastewater using microbes - PHA can be used to make biodegradable plastics - Found a paper discussing this technology (see below)
<p>Considerations</p> <p>Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p>	<ul style="list-style-type: none"> - Societal <ul style="list-style-type: none"> - If we can treat wastewater while simultaneously producing a material that can be used to make biodegradable plastics - Economic <ul style="list-style-type: none"> - Cheaper than pure culture????

<p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	<ul style="list-style-type: none"> - Using wastewater to make plastics avoids the manufacturing cost of making substrates to make PHA - Environmental <ul style="list-style-type: none"> - Biodegradable plastic is environmentally friendly! - Recycling wastewater to make PHA prevents manufacturers from consuming energy to make substrates to make PHA - Ethical <ul style="list-style-type: none"> - Ethically sound to recycle waste! - Material - Emotional <ul style="list-style-type: none"> - Recycling has a positive emotional link for many.
<p>Alternatives</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Can we use different cell types to produce a mix of PHA and another useful material?
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - Rejected

<p>Opportunity</p> <p>What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Using co-cultures to improve the tastes, quality and consistency of traditional fermented beverages - This is one of the most well-known and established use of co-cultures
<p>Considerations</p> <p>Why are you doing it?</p> <p>Why does this decision need to be made?</p>	<p>Controlling population dynamics crucial to reproducibility and properties of product</p> <p>Societal:</p> <ul style="list-style-type: none"> - Will allow home brewers to refine the

<p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	<p>taste of their products</p> <ul style="list-style-type: none"> - Simple, high impact, universally publicly understandable application <p>Economic:</p> <ul style="list-style-type: none"> - High-impact application with a very large international market - Alcohol related harm costs England around £21bn per year, (£3.5bn to NHS, £11bn tackling alcohol-related crime and £7.3bn for lost working days and productivity)³ <p>Environmental:</p> <ul style="list-style-type: none"> - Companies motivated by IP to remove all strains from their final products <p>Ethical:</p> <ul style="list-style-type: none"> - Alcohol is not be an allowed substance in the local region of all teams participating in iGEM. - Alcohol is 10% of the UK burden of disease and death, making it one of the three biggest lifestyle risk factors for disease and death in the UK, after smoking and obesity³ <p>Material:</p> <ul style="list-style-type: none"> - Shown in the wine industry that mixed culture fermentations using controlled inoculation of <i>Saccharomyces cerevisiae</i> starter cultures and non-<i>Saccharomyces</i> yeasts represent a feasible way toward improving the complexity and enhancing the particular and specific characteristics of wines <p>Emotional:</p> <ul style="list-style-type: none"> - Drinking alcohol often represents an opportunity to socialise
<p>Alternatives</p> <p>How could you do it/move forward differently?</p>	<ul style="list-style-type: none"> - Further research into metabolic

What are the options to respond to the stimulus?	engineering processes need to demonstrate a significant improvement on yield and efficiency than traditional fermentation methods.
Outcomes Who might care what you do and how you do it? What happens now?	<ul style="list-style-type: none"> - Although our circuit design is universal, we can only show proof-of-concept examples Gram-negative bacteria as we are limited by available communication systems. - Idea rejected

Protocol for Assessment of Effectiveness

De facto	Research projects are influenced by internal (cognitive, emotional, ethical) and external (social, economic, material) societal factors.	
Reflexive	Researchers experience a heightened awareness of these societal factors interacting and operating in their own decisions.	
Deliberate	Researchers change their practices after reflecting on how these societal factors do and could factor into their own decisions.	

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2. Rhu DH, Lee WH, Kim JY, Choi E. [Polyhydroxyalkanoate \(PHA\) production from waste](#). Water Sci Technol.

2003;48(8):221-8. PubMed PMID: 14682590.

3. <https://www.alcoholconcern.org.uk/help-and-advice/statistics-on-alcohol/>

Project Update 2

Activated Sludge System

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none">• Bioremediation of polluted wastewater influent in a bioreactor containing a synthetic consortia, before safe effluent released back into environment• Microorganisms naturally found in wastewater are already taken advantage of to process wastewater industrially
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>Consider the following dimensions when considering the impact of the opportunity:</p> <ul style="list-style-type: none">- Societal- Economic- Environmental- Ethical- Material<ul style="list-style-type: none">- all of the physical objects that people create and give meaning to- Emotional	<p>Clean, usable water is an important resource that is disappearing from our planet. Efficient recycling of wastewater will help address this impending environmental crisis.</p>
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<p>The Active Sludge System already uses microorganisms naturally found in waste to process wastewater. Improving this system is in an alternative to creating an entirely new bioreactor with a synthetic consortia.</p>
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	<p>Sewage treatment centres, water providers and government regulators will need to reassurance that the process actually results in safe water to implement this system.</p>

Application: Amyloid Fibrils

<p>Opportunities (created by the presentation) What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<p>- Applying our system to functional amyloid fibrils.</p> <p>- Tim Lu paper exploring the same concept</p>
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<p>-Because it involves a clear case for our technology and demonstrates the utility of our circuit</p> <p>Amyloids :</p> <p>Applications of amyloids (Scaffolds, Bio-nanocomposites (Graphene, Gold), Biosensors, Optoelectronic materials (nanowires, OLEDs), Coatings) all do not have a heavy emotional impact.</p> <p>Drug delivery via amyloid nanocages has a heavy emotional impact however health concerns already exist surrounding amyloids (e.g. alzheimer's). Further research was hence necessary and led to the conclusion that in general, there are pathogenic and non-pathogenic amyloids (curli are non-pathogenic). This technically means that safe nanocage production and use for drug delivery is possible however overcoming public perceptions of the amyloid fibrils is a challenge.</p> <p>No economic / environmental impact</p>
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Various different applications of amyloid fibrils -
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - Varies depending on the application. Patients, doctors, regulators, etc... for nanocages. For artificial cellulosome: farmers, biofuel producers, environmental regulators - We decided not to pursue the idea

	after we observed an emotional aversion to amyloids
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Game

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Design and produce a “co-culture” game as a form of outreach. - Idea spawned from playing Pokemon Go and looking into microbial consortiums in nature and applications for project
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - Need Outreach part of Human Practices for iGEM - Societal: Public generally have negative view of microbes and bacteria. Bacteria used in everyday processes. Very little known on lab practices. - Economic: Ad money? - Environmental: Anti GMO organisations might be angry - Ethical: Possibly undermine risk of bad bacteria. - Material: N/A - Emotional: Games good medium, people like games.
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<p>Use a different outreach medium, card game, book</p>
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	<p>General public, scientific community, socialists</p>

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Produce comparison data of 3 different forms of growth regulation for characterisation of each regulation system.
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Another design: exchange of growth factors rather than quorum - Growth inhibiting factor will accumulate: tag for fast degradation
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	
<p>Opportunity What are you doing?</p> <p>How did you become aware of the</p>	<ul style="list-style-type: none"> - Create a form of data acquisition for co-culture systems for use by the scientific community.

application/technology/idea?	
<p>Considerations</p> <p>Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	
<p>Alternatives</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	

Project Update 3

Opportunity	Production of amyloid fibrils <ul style="list-style-type: none"> - Controlled drug delivery (covered in no.2) - Cell-free recycling of cellulosic waste of production of starch
Considerations <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	Ethical <ul style="list-style-type: none"> - Issues of pathogenicity of amyloids (covered in project update no. 2)
Alternatives	
Outcomes	

Reflexive Logbook

Opportunity	<ul style="list-style-type: none"> - Creating a “reflexive” logbook - Rob Smith, a sociologist presented the idea to us as a way of having integrated human practices in our project
Considerations <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	<ul style="list-style-type: none"> - We are making the reflexive logbook to fulfill the requirements of integrated human practices. We want to talk to researchers and people in industry about how they would use our technology. - Integrated human practices must be fulfilled. <p>Societal</p> <ul style="list-style-type: none"> - Show that we have talked to professionals about our work. <p>Economic</p>

	<ul style="list-style-type: none"> - May be not enough details for scientists, and too much for the general public? <p>Ethical</p> <ul style="list-style-type: none"> - N/A <p>Material</p> <ul style="list-style-type: none"> - New area of our website <p>Emotional</p> <ul style="list-style-type: none"> - Making co-culture techniques more accessible
Alternatives	Searchable page on wiki, blog, video interviews on the website (with comment boxes)
Outcomes	<ul style="list-style-type: none"> - The judges at the competition will care how well it is executed. - Further research what form the logbook will take.

Opportunity	<p>Go-Culture Game</p> <ul style="list-style-type: none"> - Design and produce a “co-culture” game as a form of outreach
<p>Considerations</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material - Emotional 	<ul style="list-style-type: none"> - Need Outreach part of Human Practices for iGEM - Societal: Public generally have negative view of microbes and bacteria. Negative view on GMOs - Economic: N/A - Environmental: - Ethical: Possibly undermine risk of bad bacteria - Material: touch device in order to reach a wider range of players. Most people play games on their phones/tablets than PC - Emotional: Games are cool
Alternatives	Project a game on a short video at the Science museum, to collect feedback - N.B.

	<p>need to be properly introduced, otherwise will be rejected</p> <p>Use different medium. Book, card game, video</p>
Outcome	Public gain interest in co-cultures and consortia in nature and industry.

Project Update #4

Protocol for Reflexivity

Opportunity What are you doing? How did you become aware of the application/technology/idea?	
Considerations Why are you doing it? Why does this decision need to be made? What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity? Please consider the following dimensions: <ul style="list-style-type: none">- Societal- Economic- Environmental- Ethical- Material<ul style="list-style-type: none">- all of the physical objects that people create and give meaning to- Emotional	
Alternatives How could you do it/move forward differently? What are the options to respond to the stimulus?	
Outcomes Who might care what you do and how you do it? What happens now?	

Reflexive Logbook

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Making a reflexive logbook by interviewing stakeholders about our technology - Rob Smith told us about the concept of reflexivity.
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>Consider the following dimensions when considering the impact of the opportunity:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - We need to fulfill the integrated human practices requirement of our project. We want a process for reflexivity which other foundational teams could use in the future. - The game part of our project does not count as integrated human practices because it does not feed back into the design of the project. Therefore, a reflexive logbook will help with that. <p>Societal:</p> <ul style="list-style-type: none"> - People want to know that foundational researchers have spoken to stakeholders. <p>Economic:</p> <ul style="list-style-type: none"> - N/A <p>Environmental:</p> <ul style="list-style-type: none"> - N/A <p>Ethical:</p> <ul style="list-style-type: none"> - N/A <p>Material:</p> <ul style="list-style-type: none"> - N/A

	<p>Emotional:</p> <ul style="list-style-type: none"> - N/A
<p>Alternatives</p> <p>What have you done?</p> <p>What do you plan to do next?</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Refine the questions we want to ask to stakeholders. - Do something other than reflexivity. Figure out a way to incorporate people's opinions in some other way.
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - Social scientists, the government, and general public feel it is important that people are informed about these kinds of things. - Continue to refine the reflexive logbook.

Game

<p>Opportunity</p> <p>What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Design and produce a "co-culture" game as a form of outreach. - Idea spawned from playing Pokemon Go and looking into microbial consortiums in nature and applications for project
<p>Considerations</p> <p>Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic 	<ul style="list-style-type: none"> - Need Outreach part of Human Practices for iGEM - Societal: Public generally have negative view of microbes and bacteria. Bacteria used in everyday processes. - Economic: N/A - Environmental: - Ethical: Possibly undermine risk of bad bacteria - Material: - Emotional: Games are cool!!

<ul style="list-style-type: none"> - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	
<p>Alternatives</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<p>Use a different outreach medium, card game, book</p>
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	<p>Game players, sociologists, scientists?</p> <p>Focus on the mixing platform and microorg collecting to show use for microrgs in everyday life</p>

Project Update #5

Reflexive Logbook

Opportunity What are you doing? How did you become aware of the application/technology/idea?	<ul style="list-style-type: none">- Creating a reflexive logbook.- Rob Smith introduced us to it.
Considerations Why are you doing it? Why does this decision need to be made? What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity? Please consider the following dimensions: <ul style="list-style-type: none">- Societal- Economic- Environmental- Ethical- Material<ul style="list-style-type: none">- all of the physical objects that people create and give meaning to- Emotional	<ul style="list-style-type: none">- We need to fulfill the integrated human practices requirement of our project. We want a process for reflexivity which other foundational teams could use in the future.- The game part of our project does not count as integrated human practices because it does not feed back into the design of the project. Therefore, a reflexive logbook will help with that. <p>Societal:</p> <ul style="list-style-type: none">- People want to know that foundational researchers have spoken to stakeholders. <p>Economic:</p> <ul style="list-style-type: none">- N/A <p>Environmental:</p> <ul style="list-style-type: none">- N/A <p>Ethical:</p> <ul style="list-style-type: none">- N/A <p>Material:</p> <ul style="list-style-type: none">- N/A <p>Emotional:</p> <ul style="list-style-type: none">- N/A
Alternatives	<ul style="list-style-type: none">- Researched biotech companies to

<p>What have you done?</p> <p>What do you plan to do next?</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<p>reach out to and ask about our technology.</p> <ul style="list-style-type: none"> - Refine the questions we wanted to ask them. - Consider the public in the development of our project. - Not reach out to the public.
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - Social scientists, the government, and general public feel it is important that people are informed about these kinds of things. - Continue to refine the reflexive logbook.

Data Vis.

<p>Opportunity</p> <p>What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Developing a data visualization strategy. - Noticed that there was disconnect between different audiences when we spoke about our project. Noticed that people better understood our presentations when we added lots of animations and pictures.
<p>Considerations</p> <p>Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>Consider the following dimensions when considering the impact of the “opportunity”:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material 	<ul style="list-style-type: none"> - Scientists have difficulty speaking to each other and the public about their work. Visual media can act as a universal language. - N/A <p>Societal:</p> <ul style="list-style-type: none"> - Foundational science could be better communicated to the public. The public’s opinion should be taken into consideration when developing

<ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<p>scientific research.</p> <p>Economic:</p> <ul style="list-style-type: none"> - If the public is better informed about scientific research, it could inspire more scientists and engineers to develop new technologies and new products that benefit society. <p>Environmental:</p> <ul style="list-style-type: none"> - N/A <p>Ethical:</p> <ul style="list-style-type: none"> - N/A <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - We want to communicate to everyone about our project without getting frustrated.
<p>Alternatives</p> <p>What have you done?</p> <p>What do you plan to do next?</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Started literature review of science communication and data visualization - Determine what form factor the guide will take. - The public is already well informed about science and only care about controversy. Choose a different human practices strategy. - Continue researching visualization strategies.
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - The public wants to be informed about developments in science. - Continue researching visualizations strategies.

Game

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Design and produce a “co-culture” game as a form of outreach. - Idea spawned from playing Pokemon Go and looking into microbial consortiums in nature and applications for project
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - Need Outreach part of Human Practices for iGEM - Societal: Public generally have negative view of microbes and bacteria. Bacteria used in everyday processes. - Economic: N/A - Environmental: - Ethical: Possibly undermine risk of bad bacteria - Material: - Emotional:
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<p>Use a different outreach medium, card game, book</p>
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	

Project Update #6

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Developing a data visualization strategy. - Noticed that there was disconnect between different audiences when we spoke about our project. Noticed that people better understood our presentations when we added lots of animations and pictures.
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>Consider the following dimensions when considering the impact of the “opportunity”:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - Scientists have difficulty speaking to each other and the public about their work. Visual media can act as a universal language. - N/A <p>Societal:</p> <ul style="list-style-type: none"> - Foundational science could be better communicated to the public. The public’s opinion should be taken into consideration when developing scientific research. <p>Economic:</p> <ul style="list-style-type: none"> - If the public is better informed about scientific research, it could inspire more scientists and engineers to develop new technologies and new products that benefit society. <p>Environmental:</p> <ul style="list-style-type: none"> - N/A <p>Ethical:</p> <ul style="list-style-type: none"> - N/A <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - We want to communicate to everyone about our project without getting frustrated.

<p>Alternatives What have you done?</p> <p>What do you plan to do next?</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Furthered literature review of science communication and data visualisation. - Determine what form factor the information will take. - The public is already well informed about science and only care about controversy. Choose a different human practices strategy. - Continue researching visualization strategies.
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - The public wants to be informed about developments in science. - Continue researching visualizations strategies.

Game

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Design and produce a “co-culture” game as a form of outreach. - Idea spawned from playing Pokemon Go and looking into microbial consortiums in nature and applications for project
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental 	<ul style="list-style-type: none"> - Need Outreach part of Human Practices for iGEM - Societal: Public generally have negative view of microbes and bacteria. Bacteria used in everyday processes. - Economic: N/A - Environmental: - Ethical: Possibly undermine risk of bad bacteria - Material: - Emotional:

<ul style="list-style-type: none"> - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	
<p>Alternatives How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	Use a different outreach medium, card game, book
<p>Outcomes Who might care what you do and how you do it?</p> <p>What happens now?</p>	

Project Update #7

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Making a reflexive logbook by employing the S.T.I.R. protocol into our reflexivity practice - Rob Smith told us about the concept of reflexivity.
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - We need to fulfill the integrated human practices requirement of our project. We want a process for reflexivity which other foundational teams could use in the future. - The game part of our project does not count as integrated human practices because it does not feed back into the design of the project. Therefore, a reflexive logbook will help with that. <p>Societal:</p> <ul style="list-style-type: none"> - People want to know that foundational researchers have spoken to stakeholders. <p>Economic:</p> <ul style="list-style-type: none"> - N/A <p>Environmental:</p> <ul style="list-style-type: none"> - N/A <p>Ethical:</p> <ul style="list-style-type: none"> - N/A <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - N/A

<p>Alternatives</p> <p>What have you done?</p> <p>What do you plan to do next?</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Developed new set of questions to do reflexivity in the context of the S.T.I.R method - Create a reflexivity logbook using the S.T.I.R. protocol - Continue to reach out to businesses and researchers - Determine a way to engage the public in reflexivity - Further develop the S.T.I.R. protocol to suit our needs
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - Social scientists, the government, and general public feel it is important that people are informed about these kinds of things. - Continue to refine the reflexive logbook.

<p>Opportunity</p> <p>What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Developing a data visualization strategy. - Noticed that there was disconnect between different audiences when we spoke about our project. Noticed that people better understood our presentations when we added lots of animations and pictures.
<p>Considerations</p> <p>Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>Consider the following dimensions when considering the impact of the “opportunity”:</p> <ul style="list-style-type: none"> - Societal - Economic 	<ul style="list-style-type: none"> - Scientists have difficulty speaking to each other and the public about their work. Visual media can act as a universal language. - N/A <p>Societal:</p> <ul style="list-style-type: none"> - Foundational science could be better

<ul style="list-style-type: none"> - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<p>communicated to the public. The public's opinion should be taken into consideration when developing scientific research.</p> <p>Economic:</p> <ul style="list-style-type: none"> - If the public is better informed about scientific research, it could inspire more scientists and engineers to develop new technologies and new products that benefit society. <p>Environmental:</p> <ul style="list-style-type: none"> - N/A <p>Ethical:</p> <ul style="list-style-type: none"> - N/A <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - We want to communicate to everyone about our project without getting frustrated.
<p>Alternatives</p> <p>What have you done?</p> <p>What do you plan to do next?</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Decided that the data visualization strategy would take the form of a guidebook and infographic. We will design and present information to the public based on the literature's recommendations. We will pass it on to other iGEM teams to use to present their own projects. - Make the guidebook. Determine the content. Do more literature review. Set up presentation with the public. Ask sociologists and science communicators what they think of strategy. - The public is already well informed about science and only care about controversy. Choose a different human practices strategy.

	<ul style="list-style-type: none"> - Continue to develop the guidebook.
Outcomes Who might care what you do and how you do it? What happens now?	<ul style="list-style-type: none"> - The public wants to be informed about developments in science. - Continue researching visualizations strategies.

Game

Opportunity What are you doing? How did you become aware of the application/technology/idea?	<ul style="list-style-type: none"> - Design and produce a “co-culture” game as a form of outreach. - Idea spawned from playing Pokemon Go and looking into microbial consortiums in nature and applications for project
Considerations Why are you doing it? Why does this decision need to be made? What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity? Please consider the following dimensions: <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - Need Outreach part of Human Practices for iGEM - Societal: Public generally have negative view of microbes and bacteria. Bacteria used in everyday processes. - Economic: N/A - Environmental: - Ethical: Possibly undermine risk of bad bacteria - Material: - Emotional:
Alternatives How could you do it/move forward differently? What are the options to respond to the stimulus?	Use a different outreach medium, card game, book

<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	
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Project Update #8

Designer Biofertilizer

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<p>We are engineering stable, mixed consortia biofertilizers to boost plant growth.</p> <p>We found single populations of microorganisms are already sold as biofertilizers and as an alternative to hazardous chemicals, and different biofertilizers confer different properties to boost plant growth.</p> <p>We found biofertilizers are predicted to play a role in addressing the growing food and agriculture crisis of disappearing rural land as populations grow and megacities expand further by making agriculture more efficient and less hazardous due to harsh chemicals.</p>
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>Consider the following dimensions when considering the impact of the opportunity:</p> <ul style="list-style-type: none">- Societal- Economic- Environmental- Ethical- Material<ul style="list-style-type: none">- all of the physical objects that people create and give meaning to- Emotional	<p>Mixed consortia of biofertilizers are known to be more effective and confer a combination of functions to boost yield, but as with all synthetic consortia, it is very difficult to mix different species together.</p> <p>Agriculture is struggling to cope with the growing population and disappearance of rural land and workers to feed people. Biofertilizers can help solve this problem. Making biofertilizers better by being able to mix them will hence be crucial to improving agriculture and feeding the world.</p> <p>Mixed biofertilizers will allow more efficient agriculture with fewer hazardous chemical fertilizers. In a world with ever expanding cities, ever shrinking farmland and an ever growing population, more efficient agriculture will be crucial to feeding us. Economically, this will be a huge boost to farmers but will threaten the industries that produce chemical fertilizers. Ethically, we will be using GMOs to enhance the growth of crops which may be otherwise GMO-free, blurring the lines between a GMO product and what we</p>

	consider organic in terms of regulation.
Alternatives How could you do it/move forward differently? What are the options to respond to the stimulus?	Using less chemical fertilizers that have negative environmental consequences or alternative agriculture methods that boost plant growth while maintaining or introducing beneficial microorganisms would be possible alternatives.
Outcomes Who might care what you do and how you do it? What happens now?	Biofertilizer companies, consumers, and farmers will be affected the most by this idea. Government and lawmakers will also be affected because regulations will need to be further developed to address the use of mixed biofertilizers.

Printer Inks

Opportunity What are you doing? How did you become aware of the application/technology/idea?	<ul style="list-style-type: none"> - Developing printer inks. - Colours are mixed in precise ratios. Our genetic circuitry can manage cell populations in precise ratios. Obvious application.
Considerations Why are you doing it? Why does this decision need to be made? Consider the following dimensions when considering the impact of the “opportunity”: <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - Our genetic circuitry can manage cell populations in precise ratios. We can make precise colours by splitting the generation of primary colour pigments between cell populations. - N/A Societal: <ul style="list-style-type: none"> - Replace expensive, harsh chemicals used for printer inks. Economic: <ul style="list-style-type: none"> - Create new printer and ink cartridge system which is cheaper easier to replace than ones currently on the market. Environmental:

	<ul style="list-style-type: none"> - No more toxic chemicals released into the environment to create pigments. <p>Ethical:</p> <ul style="list-style-type: none"> - N/A <p>Material:</p> <ul style="list-style-type: none"> - Create more printers. <p>Emotional:</p> <ul style="list-style-type: none"> - Inks are cool!
Alternatives What have you done? What do you plan to do next? How could you do it/move forward differently? What are the options to respond to the stimulus?	<ul style="list-style-type: none"> - Started literature review of printer ink productions, Pantone system, how to create pigments in cells, etc. - Determine if it is feasible through discussion with researchers at the university. - Choose one of the other 11 proposed applications.
Outcomes Who might care what you do and how you do it? What happens now?	<ul style="list-style-type: none"> - Environmentalists and conscious consumers will enjoy our product. Established printer and ink makers will be disrupted by our work. - Determine if this is best application of the system and further develop it as an idea.

Data Vis.

Opportunity What are you doing? How did you become aware of the application/technology/idea?	<ul style="list-style-type: none"> - Developing a data visualization strategy. - Noticed that there was disconnect between different audiences when we spoke about our project. Noticed that people better understood our presentations when we added lots of animations and pictures.
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<p>Considerations</p> <p>Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>Consider the following dimensions when considering the impact of the “opportunity”:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - Scientists have difficulty speaking to each other and the public about their work. Visual media can act as a universal language. - N/A <p>Societal:</p> <ul style="list-style-type: none"> - Foundational science could be better communicated to the public. The public’s opinion should be taken into consideration when developing scientific research. <p>Economic:</p> <ul style="list-style-type: none"> - If the public is better informed about scientific research, it could inspire more scientists and engineers to develop new technologies and new products that benefit society. <p>Environmental:</p> <ul style="list-style-type: none"> - N/A <p>Ethical:</p> <ul style="list-style-type: none"> - N/A <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - We want to communicate to everyone about our project without getting frustrated.
<p>Alternatives</p> <p>What have you done?</p> <p>What do you plan to do next?</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Developed outline for the guidebook. Designed infographics. Set up presentation with the Royal College of Art. Identified another collaboration opportunity with Copenhagen. - Finalize guidebook. Present the infographics. - The public is already well informed about science and only care about controversy. Choose a different

	<p>human practices strategy.</p> <ul style="list-style-type: none"> - Continue to develop the guidebook and infographics.
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	<ul style="list-style-type: none"> - The public wants to be informed about developments in science. - Continue researching visualizations strategies.

Reflexive Logbook

<p>Opportunity</p> <p>What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Making a reflexive logbook by interviewing stakeholders about our technology - Rob Smith told us about the concept of reflexivity.
<p>Considerations</p> <p>Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - We need to fulfill the integrated human practices requirement of our project. We want a process for reflexivity which other foundational teams could use in the future. - The game part of our project does not count as integrated human practices because it does not feed back into the design of the project. Therefore, a reflexive logbook will help with that. <p>Societal:</p> <ul style="list-style-type: none"> - People want to know that foundational researchers have spoken to stakeholders. <p>Economic:</p> <ul style="list-style-type: none"> - N/A <p>Environmental:</p> <ul style="list-style-type: none"> - N/A <p>Ethical:</p>

	<ul style="list-style-type: none"> - N/A <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - N/A
<p>Alternatives</p> <p>What have you done?</p> <p>What do you plan to do next?</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Completed the past reflexivity
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	

Game

<p>Opportunity</p> <p>What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Design and produce a “co-culture” game as a form of outreach. - Idea spawned from playing Pokemon Go and looking into microbial consortiums in nature and applications for project
<p>Considerations</p> <p>Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity?</p> <p>Please consider the following dimensions:</p>	<ul style="list-style-type: none"> - Need Outreach part of Human Practices for iGEM - Societal: Public generally have negative view of microbes and bacteria. Bacteria used in everyday processes. - Economic: N/A - Environmental: - Ethical: Possibly undermine risk of bad bacteria

<ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - Material: - Emotional:
Alternatives How could you do it/move forward differently? What are the options to respond to the stimulus?	Use a different outreach medium, card game, book
Outcomes Who might care what you do and how you do it? What happens now?	

Opportunity What are you doing? How did you become aware of the application/technology/idea?	<ul style="list-style-type: none"> - Engineering Microbial Fuel Cells (MFCs) for wastewater treatment and energy production - Consortia of <i>Geobacter sulfurreducens</i> and <i>E. coli</i> for more efficient microbial fuel cell.
Considerations Why are you doing it? Why does this decision need to be made? What is the criteria needed to go into the decision in order to have an acceptable response to the stimulus/opportunity? Please consider the following dimensions: <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material 	<ul style="list-style-type: none"> - MFCs are a key bioenergy application of co-cultures Societal: <ul style="list-style-type: none"> - -

<ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	
<p>Alternatives</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	
<p>Outcomes</p> <p>Who might care what you do and how you do it?</p> <p>What happens now?</p>	

<p>Opportunity What are you doing?</p> <p>How did you become aware of the application/technology/idea?</p>	<ul style="list-style-type: none"> - Developing printer inks instead of financial modelling - N/A
<p>Considerations Why are you doing it?</p> <p>Why does this decision need to be made?</p> <p>Consider the following dimensions when considering the impact of the “opportunity”:</p> <ul style="list-style-type: none"> - Societal - Economic - Environmental - Ethical - Material <ul style="list-style-type: none"> - all of the physical objects that people create and give meaning to - Emotional 	<ul style="list-style-type: none"> - We believe the printer inks will yield more significant results than the modelling of financial systems. Printer inks will give a more tangible product. Printer inks are more accessible to the majority than financial markets. - We’re 4 weeks from the competition. We need a single application, because we cannot deliver two. <p>Societal:</p> <ul style="list-style-type: none"> - Printer inks are more immediately useful to the majority than financials. (Financials are more immediately useful only to those in the sector). - In the long term improved modelling of financials could impact the general public. <p>Economic:</p> <ul style="list-style-type: none"> - Printer inks will affect the economy of the ink production industry specifically. - Printer ink could see a rise in the investments into synthetic biology research. - Financials would not have an immediate effect on the economy. - More accurate modelling could allow for improved economic forecasts. - In conclusion the economic effects of printer inks is more immediate and measureable than that of financial modelling. <p>Environmental:</p>

	<ul style="list-style-type: none"> - Printer ink results in no more toxic chemicals released into the environment to create pigments. - Financials has no environmental impact. - Printer ink therefore has a stronger environmental impact. <p>Ethical:</p> <ul style="list-style-type: none"> - N/A <p>Material:</p> <ul style="list-style-type: none"> - N/A <p>Emotional:</p> <ul style="list-style-type: none"> - The general public probably has a higher emotional investment in the financial markets than in printer ink because people care a lot about their own finances.
<p>Alternatives</p> <p>What have you done?</p> <p>What do you plan to do next?</p> <p>How could you do it/move forward differently?</p> <p>What are the options to respond to the stimulus?</p>	<ul style="list-style-type: none"> - Held a vote among the team and among supervisors separately to distinguish which is the more favourable idea. - Compared feasibility by writing high level experimental designs for each and comparing. - Carry forward the printer ink application into the lab as a concrete demonstration of our project. - Model the financial systems at a high level to visualise and demonstrate the potential of our product in this application field. - Not to carry financial models into the lab as we lack the time and resources. - Moving forward differently could include carrying forward financial modelling instead of printer ink - It could also include choosing another of the 12 applications - Or it could include coming up with a

	new application altogether
Outcomes Who might care what you do and how you do it? What happens now?	<ul style="list-style-type: none"> - Environmentalists and conscious consumers will enjoy our product. Established printer and ink makers will be disrupted by our work. - Those that voted for financial modelling and would prefer to have done that application may feel less enthusiastic about printer ink and could hence put less work into this application and feel demoralised. - Further develop it as an idea, particularly focusing on how to sell the application. - Begin experiments for printer inks.